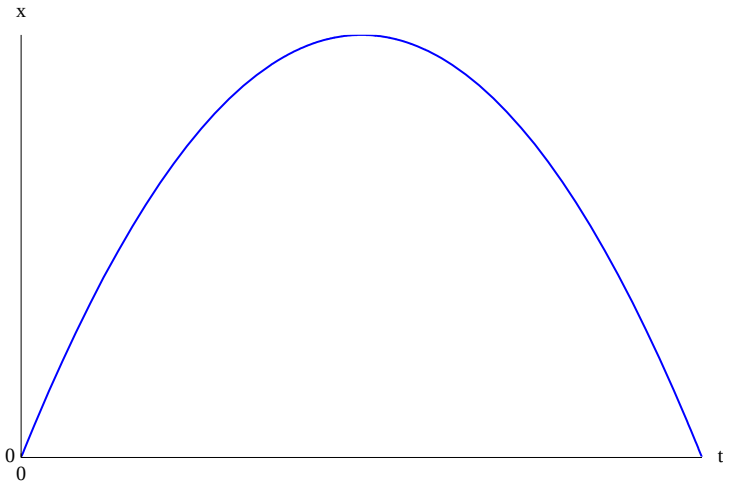
K.A. Tsokos

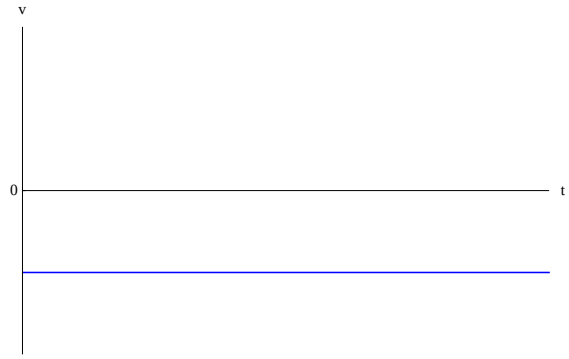
Specimen Paper 1 HL

Section A

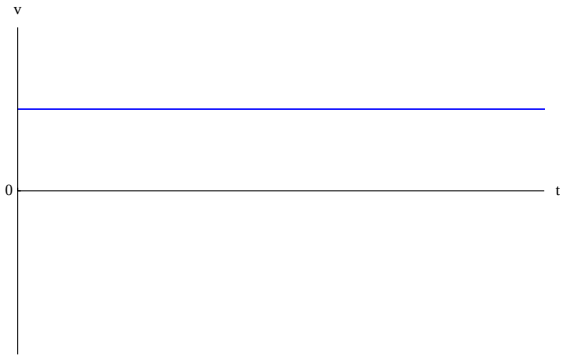
1 The graph shows the variation of the position *x* of an object with time *t*.



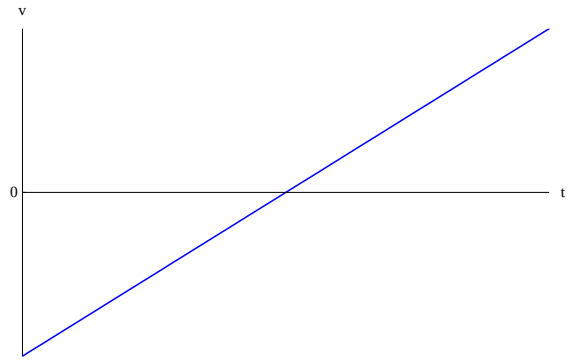
Which graph shows the variation with time of the velocity of the object.



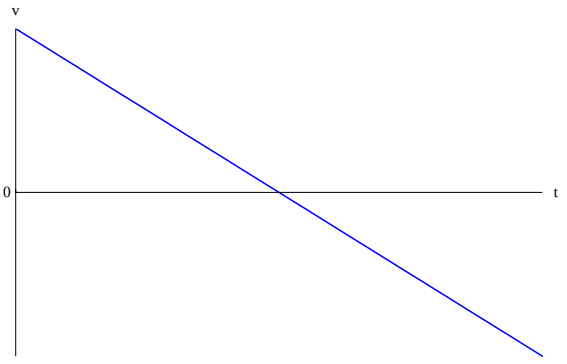
A



B

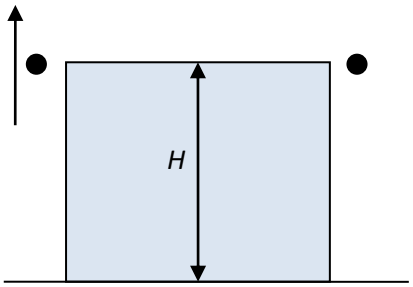


C



D

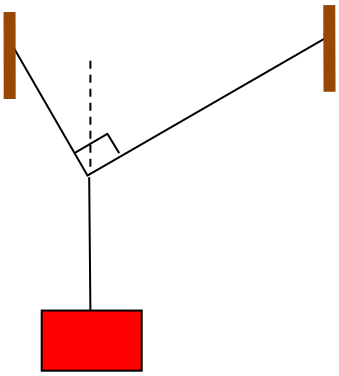
2 A ball is thrown upwards with speed 7.5 m s^{-1} from a height *H* above ground. One second later an identical ball is dropped from the same height. Air resistance is ignored.



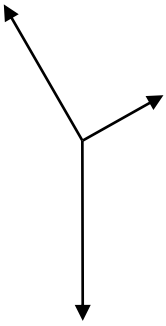
The two balls arrive on the ground at the same time. What is *H*?

A 3.0 m **B** 5.0 m **C** 10 m **D** 15 m

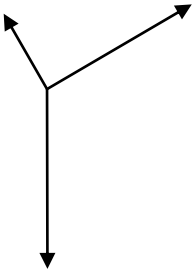
3 A block is held in equilibrium by two strings as shown.



Which is the correct free body diagram for the point where the strings join?

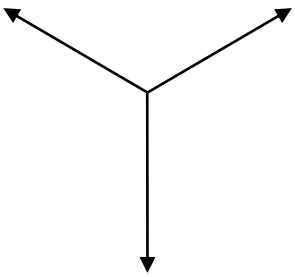


A



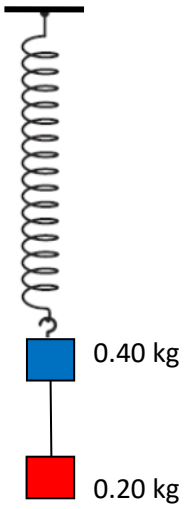
B

C



D

4 Two blocks of mass 0.40 kg and 0.20 kg are joined by a string and hang at the end of a spring of negligible mass.



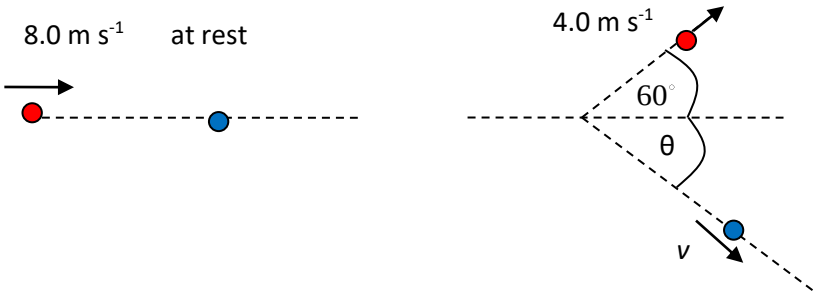
The string is cut. What is the initial acceleration of the upper block?

A 3.0 m s^{-2} **B** 5.0 m s^{-2} **C** 10 m s^{-2} **D** 15 m s^{-2}

5 A ball of weight W accelerates vertically down under the action of an air resistance force F. What is the magnitude of the rate of change of momentum of the ball?

A 0 **B** W **C** $W+F$ **D** $W-F$

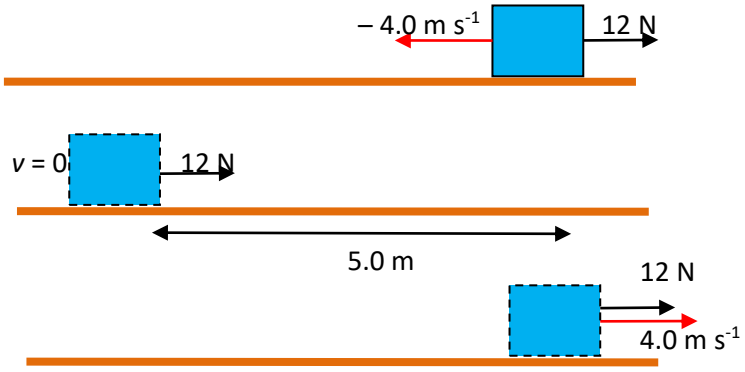
6 A red ball moving at 8.0 m s^{-1} collides with a blue ball of the same mass. The red ball scatters at an angle 60° and the blue ball moves off at an angle θ as shown.



Which set of equations expresses momentum conservation in the horizontal and vertical directions?

	***x*-direction**	***y*-direction**
A	$8=4\sin 60^\circ+v\sin\theta$	$0=4\cos 60^\circ-v\cos\theta$
B	$8=4\sin 60^\circ+v\sin\theta$	$0=4\sin 60^\circ-v\sin\theta$
C	$8=4\cos 60^\circ+v\cos\theta$	$0=4\cos 60^\circ-v\cos\theta$
D	$8=4\cos 60^\circ+v\cos\theta$	$0=4\sin 60^\circ-v\sin\theta$

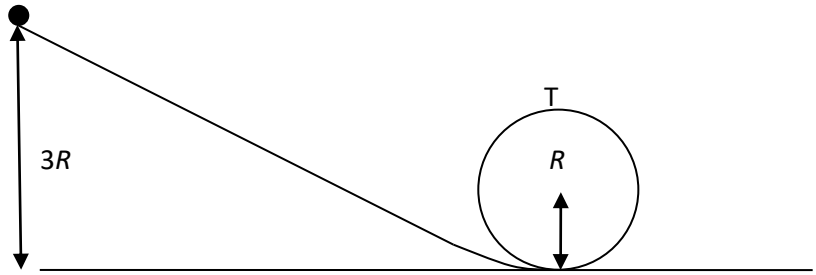
7 A body moving along a straight line has a velocity of – 4.0 m s^{-1}. A constant net force of 12 N directed to the right changes the velocity of the body to + 4.0 m s^{-1} as shown.



What is the work done by this force?

A – 60 J **B** 0 **C** 60 J **D** 120 J

8 In a loop-the-loop toy, a point particle of weight W is released from a height $3R$ where R is the radius of the loop.



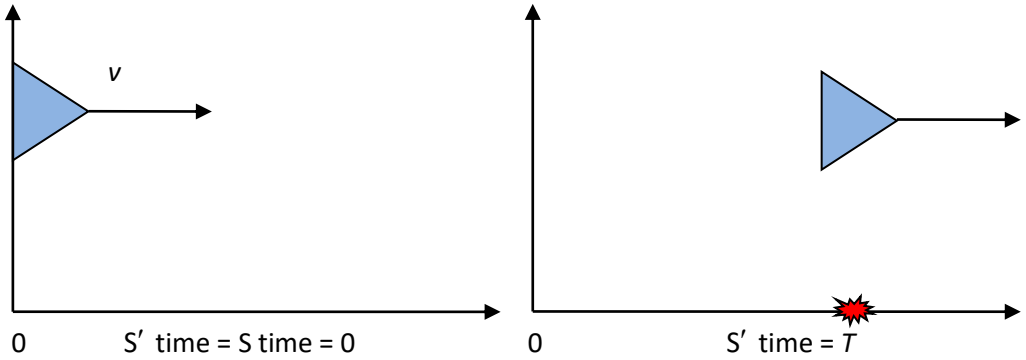
What is the normal force from the loop on the particle at point T?

A $\frac{W}{2}$ **B** W **C** $2W$ **D** $5W$

9 A body of moment of inertia 4.0 kg m^2 is acted upon by a torque 8.0 N m. The body is initially at rest. What is the angular speed of the body after 6.0 s?

A $\frac{16}{3}\,\text{rads}^{-1}$ **B** $3.0\,\text{rads}^{-1}$ **C** $12\,\text{rads}^{-1}$ **D** $24\,\text{rads}^{-1}$

10 A rocket (frame S′) goes past the ground (frame S) with speed *v*. When the S′ clocks show *T* an explosion takes place below S′.



The gamma factor for the speed *v* is γ. Where and when does the explosion take place according to S?

	Position	Time
A	γvT	γT
B	γvT	$\frac{T}{\gamma}$
C	$-\gamma vT$	γT
D	$-\gamma vT$	$\frac{T}{\gamma}$

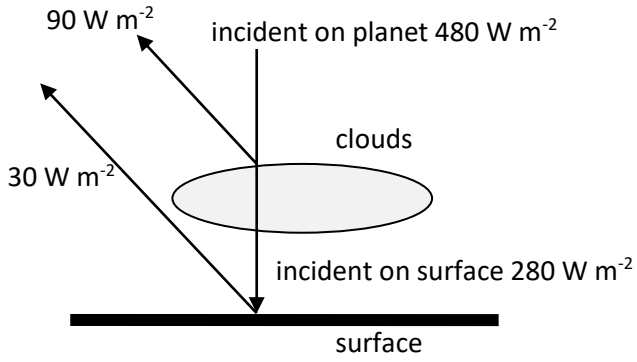
11 Liquid water and steam coexist at $100\,^{\circ}\text{C}$. How does the average random kinetic energy and intermolecular potential energy of the particles in 1 g of liquid water compare with that of the particles in 1 g of steam?

	Average random kinetic energy	Intermolecular potential energy
A	Same	Same
B	Same	Greater for steam
C	Greater for steam	Same
D	Greater for steam	Greater for steam

12 The pressure and density of an ideal gas at kelvin temperature *T* are both doubled. What is the new temperature of the gas?

A $\frac{T}{4}$ **B** $\frac{T}{2}$ **C** T **D** $2T$

13 The diagram represents the energy balance of a planet of constant temperature. The upward arrows represent reflected intensities.



What is the albedo of the planet and what is the total radiated intensity into space?

	albedo	**Radiated intensity into space /W m^{-2}**
A	0.20	200
B	0.20	360
C	0.25	200
D	0.25	360

14 A system performs 500 J of work and it rejects 300 J of thermal energy into the surroundings. What is the change in the internal energy of the system?

A −800 J **B** −200 J **C** +200 J **D** +800 J

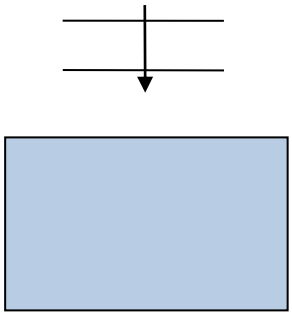
15 A Carnot engine operates with an ideal gas between a high temperature of 800 K and a low temperature *T*. The efficiency of the engine is 0.60.
What is *T* and what can be said about the total change in the entropy of the gas in one cycle?

	T	**Entropy**
A	320 K	Does not change
B	320 K	Increases
C	480 K	Does not change
D	480 K	Increases

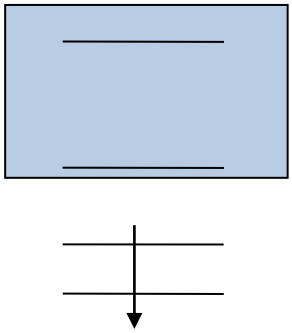
16 The displacement of a particle executing simple harmonic oscillations is given by $x = x_0 \sin(\omega t + \frac{\pi}{2})$. What is the velocity of the particle at time $t = \frac{T}{2}$ where T is the period?

A $-\omega x_0$ **B** 0 **C** $\frac{\omega x_0}{2}$ **D** ωx_0

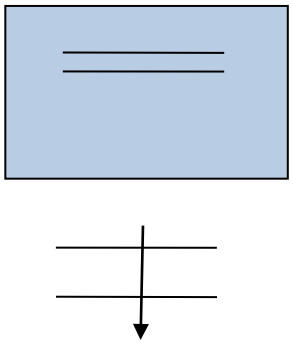
17 Two wavefronts of a light wave are incident on a rectangular glass block.



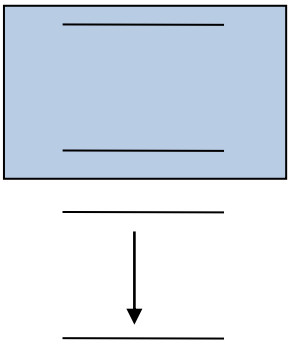
Which diagram correctly shows the wavefronts inside the block and after they have left the block?



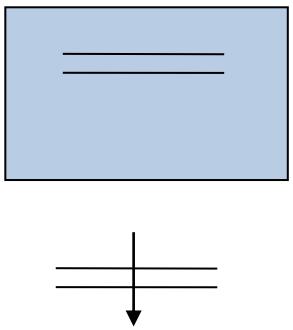
A



B



C

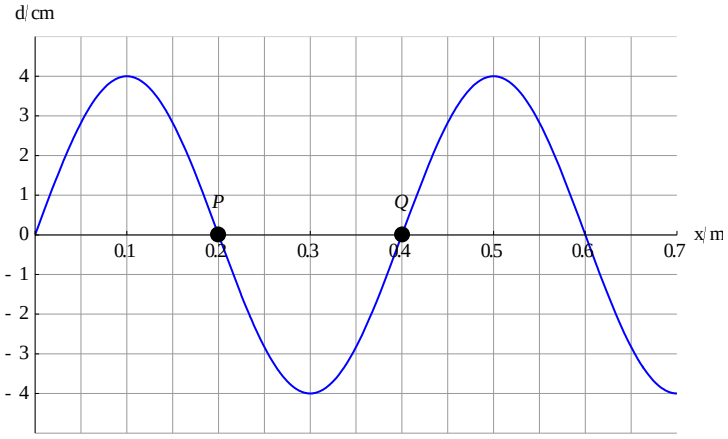


D

18 A damped oscillating system is acted upon by an external periodic force of frequency f. What is correct about the amplitude of oscillations of the system as the frequency f becomes very small or very large?

	***f* small**	***f* large**
A	Approaches zero	Approaches zero
B	Approaches zero	Approaches non zero constant
C	Approaches non zero constant	Approaches zero
D	Approaches non zero constant	Approaches non zero constant

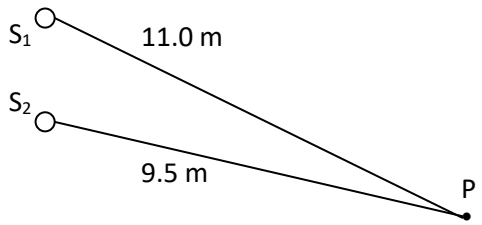
19 Two points, P and Q, have been marked on a travelling wave.



What is the phase difference between P and Q?

A 0 **B** $\frac{\pi}{4}$ **C** $\frac{\pi}{2}$ **D** π

20 S_1 and S_2 are sources of sound of wavelength 3.0 m. The two sources emit waves in phase. The amplitude of each source separately at P is x_0.



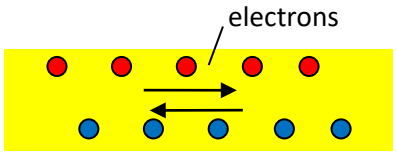
What is the amplitude at P?

A 0 **B** $\frac{x_0}{2}$ **C** x_0 **D** $2x_0$

21 Light is incident on a diffraction grating. The second order maximum corresponding to a wavelength of 660 nm coincides with the third order maximum of a wavelength λ. What is λ?

A 220 nm **B** 330 nm **C** 440 nm **D** 960 nm

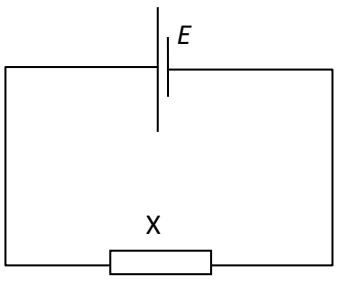
22 *N* electrons per second move through the cross sectional area of a liquid conductor. The same number of positive charge carriers (each of charge *e*) moves through the cross sectional area per second in the opposite direction.

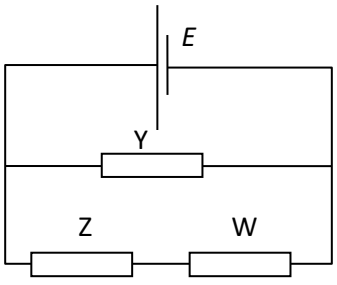


What is the current in the conductor and what is the direction of the electric field in the conductor?

	Current	Electric field direction
A	0	→
B	0	←
C	2*Ne*	→
D	2*Ne*	←

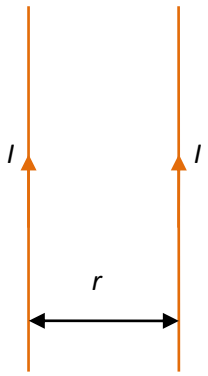
23 In both circuits the cells have the same emf *E* and no internal resistance. All 4 resistors have the same resistance. The power dissipated in resistor X is 60 W. What is the power dissipated in resistor Y?





A 20 W **B** 40 W **C** 60 W **D** 90 W

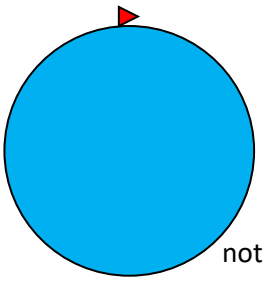
24 Two long parallel wires separated by a distance r carry the same current I in the same direction.



The force per unit length on each wire is f. The separation and the current in each wire are all doubled. What is the new force per unit length on each wire?

A $4f$ **B** $2f$ **C** $\frac{f}{2}$ **D** $\frac{f}{4}$

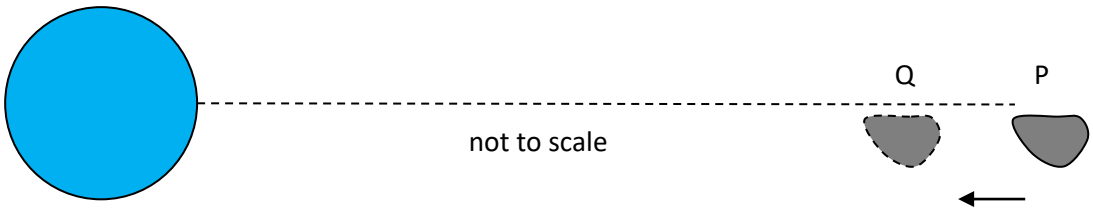
25 A spacecraft is in a grazing orbit around the Earth, i.e. the orbit radius is essentially the radius R of the Earth. The gravitational field strength at the surface is g.



What is the period of revolution of the spacecraft?

A $2\pi\sqrt{\frac{R}{g}}$ **B** $2\pi\sqrt{\frac{g}{R}}$ **C** $4\pi^2\frac{R}{g}$ **D** $4\pi^2\frac{g}{R}$

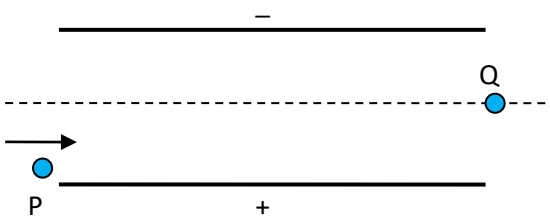
26 An asteroid approaches a planet along the dotted line. The speed of the asteroid at P is 16 km s^{-1} and at Q 20 km s^{-1}. The distance between P and Q is 4.0×10^5 km.



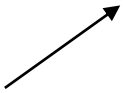
What is the average value of the gravitational field strength between P and Q?

A 0.018 Nkg^{-1} **B** 0.18 Nkg^{-1} **C** 1.8 Nkg^{-1} **D** 18 Nkg^{-1}

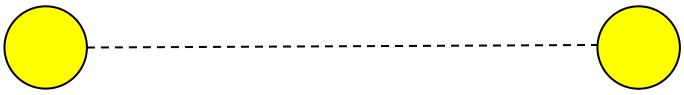
27 A proton enters the region between two oppositely charged parallel plates at point P. The proton exits the plates at Q, midway between the plates. The potential difference between the plates is *V*.



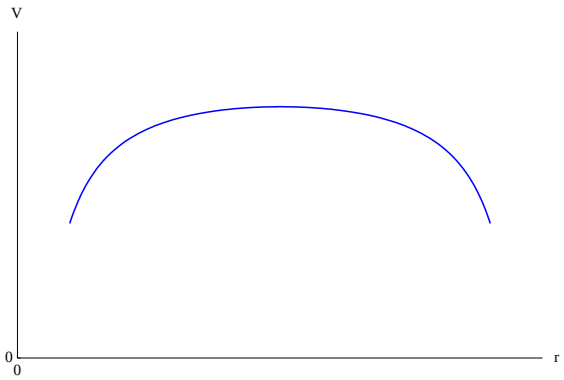
What is the change in the kinetic energy of the proton and what is the direction of the impulse delivered to the proton from P to Q?

	Change in kinetic energy	Direction of impulse
A	eV	
B	eV	
C	$\frac{eV}{2}$	
D	$\frac{eV}{2}$	

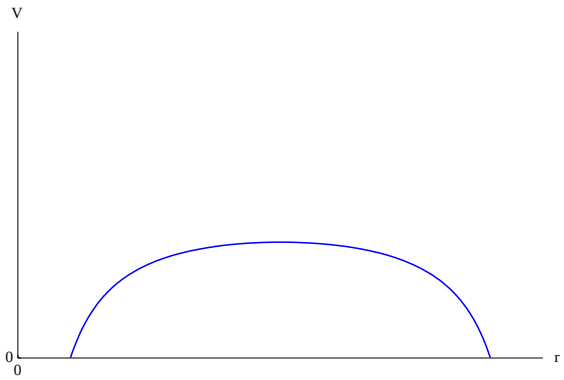
28 Two identical spheres have the same positive charge on their surfaces.



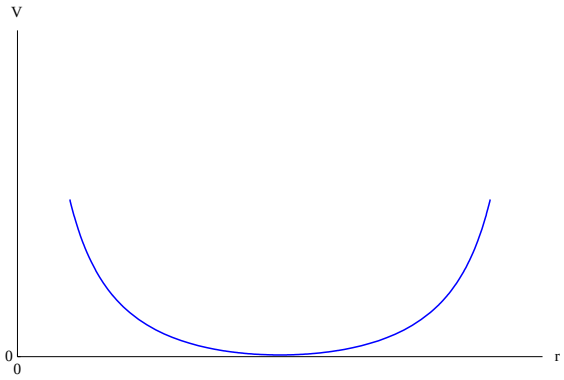
Which graph correctly shows the variation of the electric potential due to the two spheres along the dotted line?



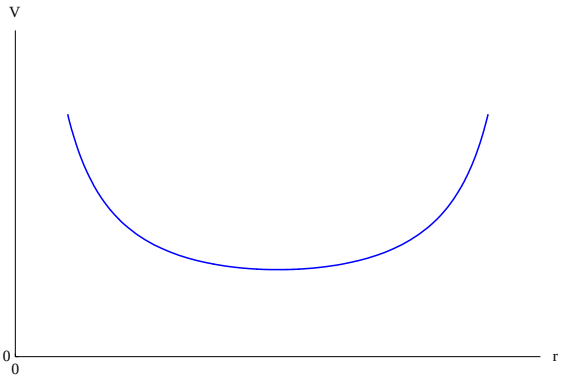
A



B

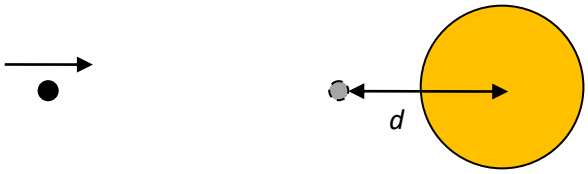


C



D

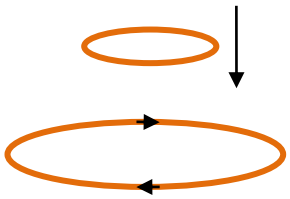
29 A proton is directed towards a stationary gold nucleus. The distance of closest approach is d_p. The electric potential energy of the proton at the point of closest approach is E_p.



The proton is replaced by an alpha particle of the same kinetic energy. The distance of closest approach for the alpha particle is d_α and its potential energy there is E_α? Which is a correct comparison?

	Distance of closest approach	Potential energy
A	$d_\alpha > d_p$	$E_\alpha = E_p$
B	$d_\alpha > d_p$	$E_\alpha < E_p$
C	$d_\alpha < d_p$	$E_\alpha = E_p$
D	$d_\alpha < d_p$	$E_\alpha < E_p$

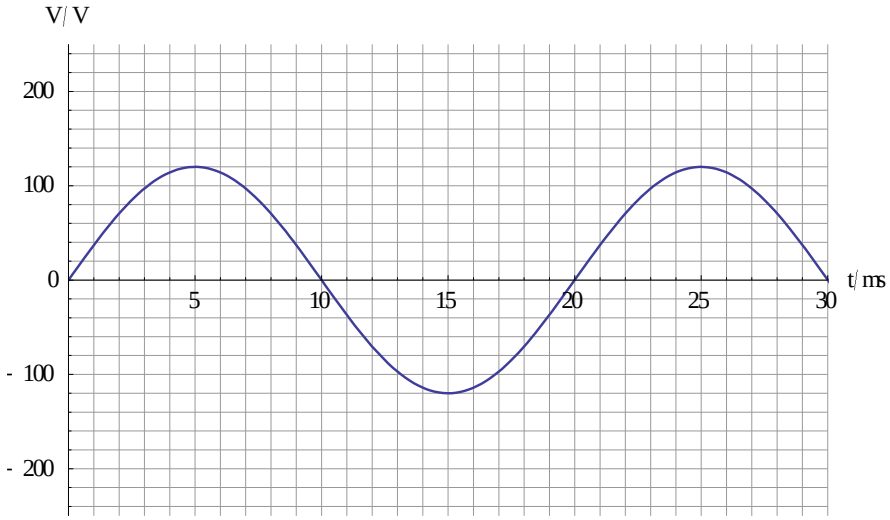
30 A small conducting ring falls through a larger horizontal ring. There is a constant clockwise current in the larger ring when looked at from above.



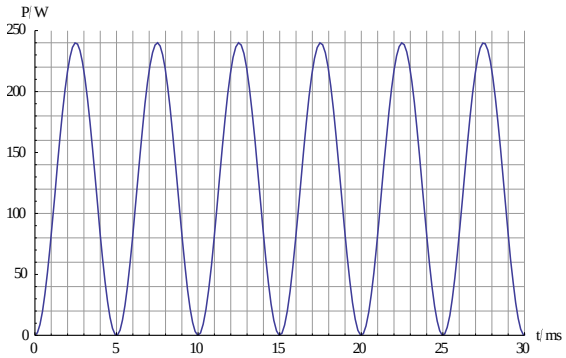
Looked at from above, what is the direction of the current induced in the smaller ring as it enters and exits the larger ring?

	Ring enters	Ring exits
A	clockwise	clockwise
B	clockwise	counter-clockwise
C	counter-clockwise	clockwise
D	counter-clockwise	counter-clockwise

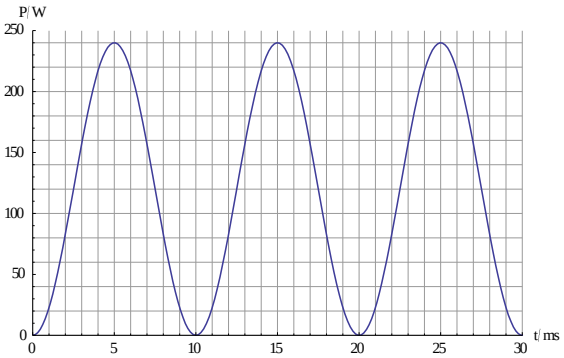
31 The graph shows the variation with time of the voltage in a generator.



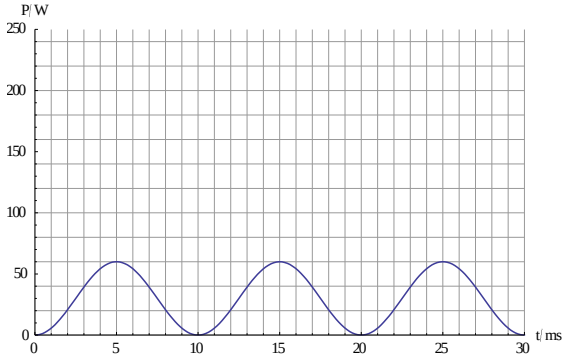
The generator is connected to an external resistor of resistance 240 Ω. Which graph shows the variation with time of the power dissipated in the external resistor when the frequency of rotation of the generator is doubled?



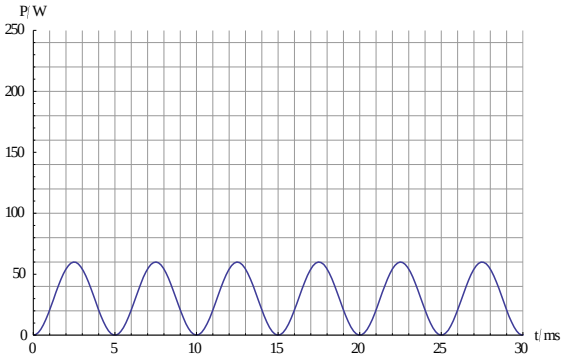
A



B



C



D

32 The speed of an electron in the n^{th} state of hydrogen is v_n. What is $\frac{v_2}{v_1}$?

A $\frac{1}{4}$ **B** $\frac{1}{2}$ **C** 2 **D** 4

33 What is a correct comparison between the electric force and the strong nuclear force between two protons separated by a distance R?

A The electric force is larger than the strong force for all R.

B The electric force is smaller than the strong force for all R.

C The electric force is larger than the strong force for very large R.

D The electric force is larger than the strong force for very small R.

34 The nucleus $^{24}_{12}\text{Mg}$ has radius R and density ρ. What are the radius and density of the nucleus $^{192}_{77}\text{Ir}$?

	Radius	Density
A	$8R$	8ρ
B	$8R$	ρ
C	$2R$	8ρ
D	$2R$	ρ

35 Where is the wave nature of the electron apparent?

A In the photoelectric effect
B In Compton scattering
C In the Bohr model of hydrogen
D In diffraction in crystals

36 A photon causes the emission of an electron with kinetic energy 1.2 eV from a metallic surface S. When the frequency of the photon is doubled, the electron emitted from S has kinetic energy 3.2 eV. What is the work function of S?

A 1.0 eV **B** 0.8 eV **C** 0.4 eV **D** 0.2 eV

37 Three factors are being considered for the plasma in a future commercial production of energy by nuclear fusion:

I High temperature
II High density
III Long confinement time

Which factors are necessary for the sustained production of energy?

A I and II only
B I and III only
C II and III only
D I, II and III

38 What is the characteristic that determines the evolution of a star past the main sequence?

A The mass

B The surface temperature

C The radius

D The luminosity

39 What is the likely end product in the evolution of our Sun?

A A neutron star

B A planetary nebula

C A white dwarf

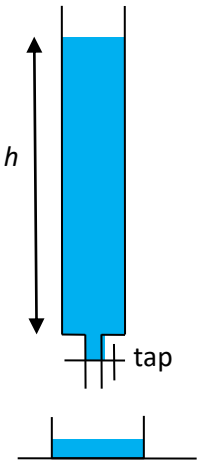
D A black hole

40 Stars X and Y have the same luminosity. The parallax angle of X is $0.02''$ and that of Y is $0.04''$. What is the ratio $\frac{b_X}{b_Y}$ of the apparent brightness of X to that of Y?

A $\frac{1}{4}$ **B** $\frac{1}{2}$ **C** 2 **D** 4

Section B [20 marks]

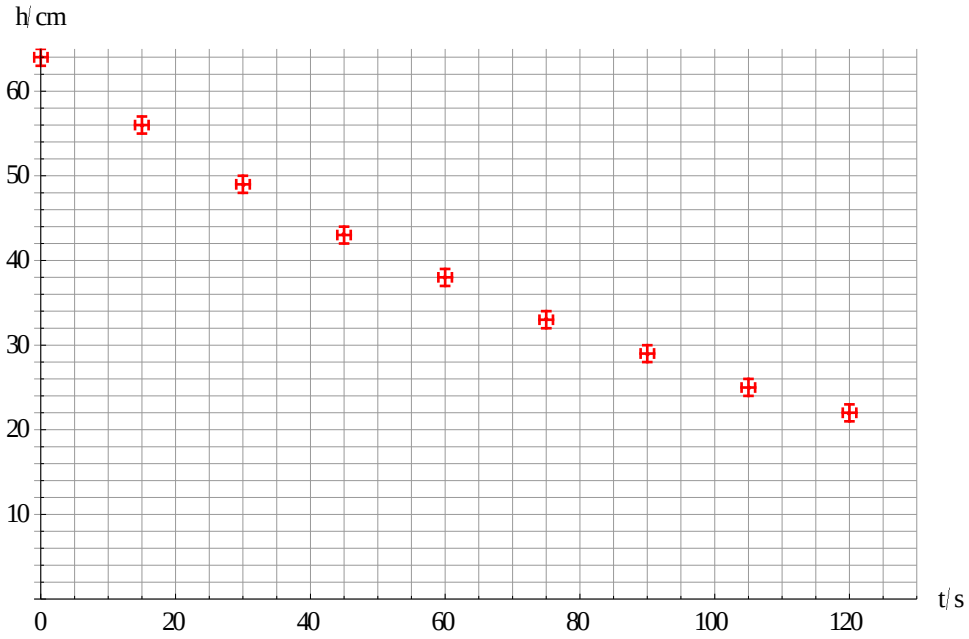
1 Students investigate the flow of water out of a burette. They open the tap to start the flow of water at $t = 0$ and then measure the height h of the water column at time t. Theory suggests that the height h depends on time t according to $h = h_0 e^{-kt}$ where h_0 is the initial height and k is a constant.



They collect the data shown in the table.

t/s ±1 s	0	15	30	45	60	75	90	105	120
h/cm ±1 cm	64	56	49	43	38	33	29	25	22

The data are plotted in a graph.



(a)

(i) State the unit of k. [1]

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……

(ii) Calculate the largest percentage uncertainty in h. [2]

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……

(iii) Estimate the time $T_{1/2}$ at which the height becomes half its initial value. [2]

……

……

(iv) The constant k is given by $k = \frac{\ln 2}{T_{1/2}}$. Calculate k. [1]

……

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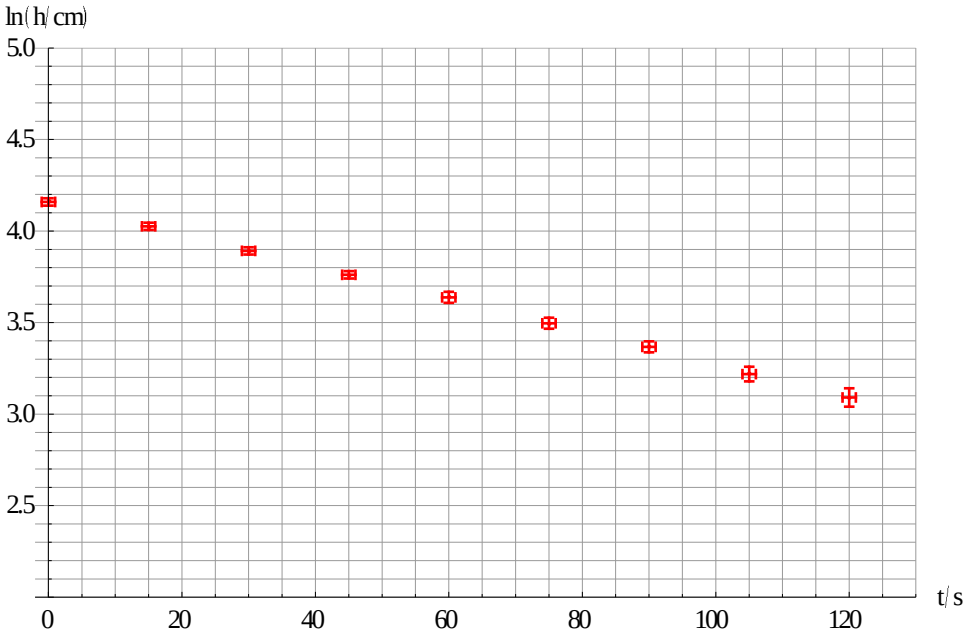
(b) The students decide to plot $\ln h$ against t. They obtain the following graph.



(i) Use the graph to calculate *k* and its uncertainty. [4]

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(ii) Suggest why this value of *k* is more reliable than the estimate in (a) (iv). [2]

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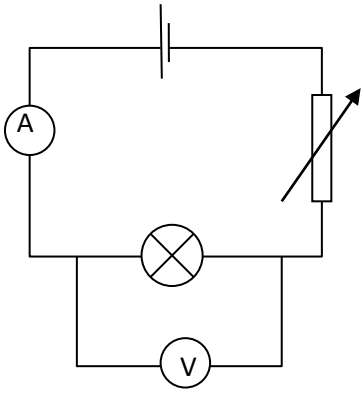
2 In an experiment to investigate the Stefan-Boltzmann radiation law, a light bulb was connected to a cell and the current through it was varied using a variable resistor.



By measuring the resistance of the light bulb and knowing the temperature coefficient of resistance of the filament the temperature of the filament was established. The power of the light bulb was found by multiplying the voltage by the current.

The following data table was constructed.

Temperature/$\times 10^3$ K $\pm$ 0.03$\times 10^3$	**Power/W** $\pm$0.5 W
0.44	0.1
0.52	0.2
0.71	0.6
1.04	1.7
1.28	3.0
1.53	4.4
1.74	7.0
1.85	8.1
1.94	10.5
2.07	12.8
2.14	15.0
2.23	18.0

The expected relationship between P and T according to the Stefan-Boltzmann law is $P \propto T^4$.

(a)

(i) State another method by which the filament loses thermal energy. [1]

……

……

(ii) The student decided to ignore data points with $T < 1000\ \text{K}$. Suggest a reason for this. [1]

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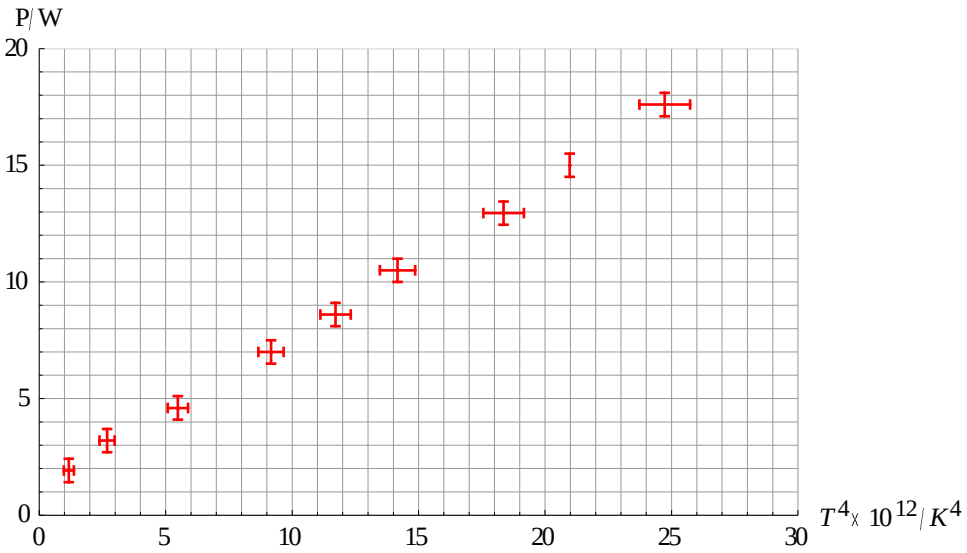
(b) A graph of P against T^4, with data points with $T < 1000\ \text{K}$ removed, is drawn.



(i) Calculate the uncertainty in T^4 for the data point with $T = 2.14 \times 10^3\ \text{K}$. [2]

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(ii) Suggest why the data do not support the expectation that the lamp filament obeys the Stefan-Boltzmann law. [1]

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(iii) A student says that there is a systematic error in the experiment. Outline a possible source of this error. [1]

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(iv) State and explain whether, after correcting for this error, it would be more or less likely to deduce that the filament lamp actually does obey the Stefan-Boltzmann law. [2]

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K.A. Tsokos

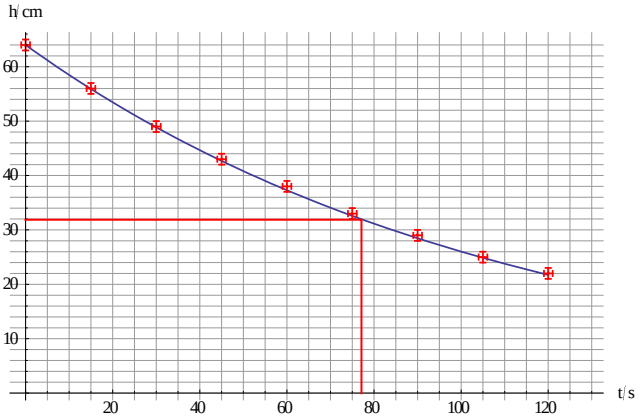
Markscheme

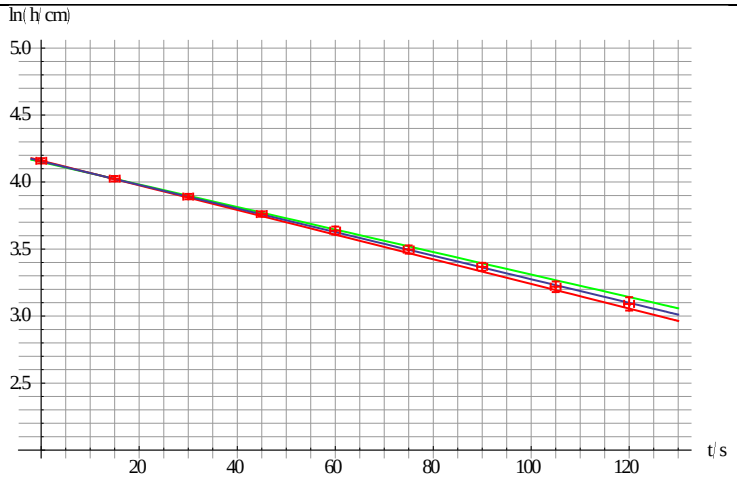
Section A

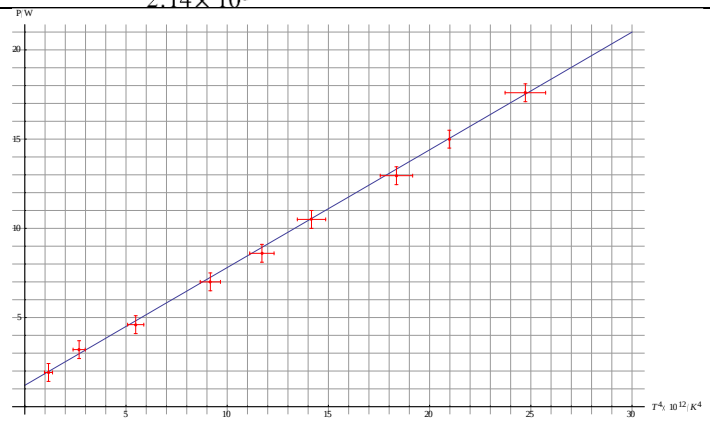
1	D		11	B		21	C		31	A
2	B		12	C		22	D		32	B
3	A		13	D		23	C		33	C
4	B		14	A		24	B		34	D
5	D		15	A		25	A		35	D
6	D		16	B		26	B		36	B
7	B		17	B		27	C		37	D
8	B		18	C		28	D		38	A
9	C		19	D		29	A		39	C
10	A		20	A		30	C		40	A

A: 10, B: 11, C: 9, D: 10

Section B

1				
a	i	s^{-1}✓		[1]
a	ii	Chooses smallest value of h✓ $\frac{\Delta(h)}{h}=\frac{1}{22}\times 100\%=4.5\%$ ✓	Accept BCA	[2]
a	iii	Draw curve of best fit: ✓  77.5 s✓	Accept time in range 75 s to 80 s	[2]
a	iv	$\frac{\ln 2}{77.5}=8.9\times 10^{-3}\ s^{-1}$ ✓	Accept range $8.7\times 10^{-3}\ s^{-1}$ to $9.2\times 10^{-3}\ s^{-1}$	[1]
b	i	Draws line of best fit and lines of min and max slope✓	Final answer for k consistent with max/min slopes	[4]

		 Best fit slope = 8.8×10^{-3} s^{-1} ✓ Max/min slopes = -9.2×10^{-3} s^{-1} / -8.4×10^{-3} s^{-1} ✓ $k=(8.8\pm0.4)\times10^{-3}$ s^{-1} ✓		
b	ii	This value uses all points not just one✓ And gives an estimate of the range of possible values through the uncertainty✓		[2]

2				
a	i	Convection✓	Do not accept conduction	[1]
a	ii	Radiation is significant/dominant at large temperatures✓		[1]
b	i	$\frac{\Delta(T^4)}{T^4}=4\frac{\Delta T}{T}$ ✓ $\Delta(T^4)=4\times\frac{30}{2.14\times10^3}\times(2.14\times10^3)^4\approx1.2\times10^{12}$ K✓		[2]
b	ii	 $P\propto T^4$ implies a straight line of best fit through the origin, which is not the case ✓		[1]
b	iii	Since the filament loses energy by convection the actual power due to radiation is less✓	Accept any other reasonable statement	[1]
b	iv	It is more likely✓ Since the values for power will be less, shifting the graph closer to the origin✓	ECF from answer to b iii	[2]